KM3NeT INFRADEV – H2020 – 739560

KM3NeT report on Pilot Exchange Program

KM3NeT-INFRADEV GA DELIVERABLE: D6.5

Document identifier:	**KM3NeT-INFRADEV-WP6-D6.5**
Date:	**18/11/2019**
Work package:	**WP6**
Lead partner:	**UVEG**
Document status:	**Final**
Dissemination level:	**Public**
Document link:	

Abstract

The main issues for a scientific exchange program addressing experts outside the KM3NeT Collaboration and allowing KM3NeT scientists to spend guest researcher stays at non-KM3NeT institutions have been explored. This program, to be financed through the future legal entity representing KM3NeT, requires to set up a corresponding legal framework, material and procedures for advertising the opportunities, as well as setting up selection criteria for the candidates and a selection committee. The program has been tested for three pilot cases – one PhD student, one junior and one senior researcher.

I. Copyright notice

II. Delivery slip

	Name	Partner	Date
Author(s)	T. Thakore, R. Gozzini, J. D. Zornoza	UVEG / WP6	18/11/2019
Approved by	PMB and KM3NeT IB		09/12/2019

III. Document log

Issue	Date	Comment	Author/Partner
1.0	27/09/2019	Initial draft	T. Thakore/UVEG
1.1	1/10/2019	Selection of candidates. Group picture.	J.D. Zornoza/UVEG
1.2	1/10/2019	Completed with combined analysis details	S.R. Gozzini/UVEG
1.3	18/10/2019	Revision	J.D. Zornoza/UVEG
1.4	21/10/2019	Activities of Master students in Italy	M. Anghinolfi/INFN-Genova
1.5	14/11/2019	Comments by Uli Katz incorporated	U.Katz/Univ. Erlangen J.D. Zornoza
1.6	18/11/2019	Further comments by Uli Katz incorporated	U.Katz/Univ. Erlangen J.D. Zornoza

IV. Application area

This document is a deliverable for the grant agreement of the project, applicable to all members of the KM3NeT-INFRADEV project, beneficiaries and third parties, as well as its collaborating projects.

V. Terminology

ARCA	=	Astroparticle Research with Cosmics in the Abyss (KM3NeT neutrino particle physics detector)
DUNE	=	Deep Underground Neutrino Experiment
Hyper-K	=	Hyper-Kamiokande
IIHE	=	Interuniversity Institute for High Energies
NOνA	=	NuMI Off-Axis ν_e Appearance
ORCA	=	Oscillation Research with Cosmics in the Abyss (KM3NeT neutrino particle physics detector)
PEP	=	Pilot Exchange Program
T2K	=	Tokai to Kamioka
WG	=	Working group

VI. List of figures

VII. List of tables

VIII. Project summary

KM3NeT is a large Research Infrastructure that will consist of a network of deep-sea neutrino telescopes in the Mediterranean Sea with user ports for earth and sea sciences. Following the appearance of KM3NeT 2.0 on the ESFRI roadmap 2016 and in line with the recommendations of the Assessment Expert Group in 2013, the KM3NeT-INFRADEV project addresses the Coordination and Support Actions (CSAs) to prepare a legal entity and appropriate services for KM3NeT, thereby providing a sustainable solution for the operation of the research infrastructure during ten (or more) years. The KM3NeT-INFRADEV project is funded by the European Commission's Horizon 2020 framework and its objectives comprise, amongst others, the Work Package "*KM3NeT in the Global Science context",* with the objective to establish a sustainable cooperation of KM3NeT with adjacent science communities.

IX. Executive summary

The KM3NeT neutrino telescope is currently under construction in the Mediterranean Sea. It will make cutting-edge observations in neutrino oscillation physics, high energy astrophysical neutrinos, dark matter, and sea sciences. These science goals of KM3NeT are linked to a variety of different fields of expertise which in turn are represented by different science communities, each with their individual tools, procedures, communication and dissemination channels, and research cultures. The objective of this WP is to establish a sustainable cooperation of KM3NeT with these communities and thus to make available to KM3NeT their respective expertise and tools, as well as to disseminate KM3NeT data and measurement opportunities to them. In particular, this requires organizing workshops and exchanges of scientists between KM3NeT and external institutions. This report describes the activities being carried out under the Pilot Exchange Program (PEP) under the current working package.

X. Table of contents

1 Introduction

The Kilometer Cube Neutrino Telescope (KM3NeT) is a next generation neutrino telescope built on the success of the ANTARES telescope. It will be deployed at two sites in the Mediterranean Sea. The first site, located off the coast of France, will host the low-energy detector configuration, called ORCA. The second site is located off the coast of Italy and will host the high-energy detector configuration, called ARCA.

The ORCA configuration aims to determine the neutrino mass hierarchy with a 3σ statistical significance with 3 years of runtime with atmospheric neutrinos. It will also make precision measurements of the atmospheric oscillation parameters and search for non-standard physics scenarios, such as Non-Standard Interactions (NSIs), sterile neutrinos, Lorentz Invariance Violation and quantum decoherence. ORCA will be a complementary neutrino experiment to the forthcoming accelerator experiments DUNE, Hyper-K as well as the reactor experiment JUNO. ARCA will observe very high-energy neutrinos from astrophysical sources such as gamma ray bursts and blazars. It will also perform indirect searches for dark matter. The technical details of the detector and main physics goal can be found in the KM3NeT 2.0 Letter of Intent [1]. The deployment of KM3NeT detection lines started in December 2015.

These science goals of KM3NeT – such as neutrino astronomy, neutrino physics, dark matter searches, and earth and sea sciences – are linked to a variety of different fields of expertise which in turn are represented by different science communities, each with their individual tools, procedures, communication and dissemination channels, and research cultures. Furthermore, in order to accomplish the goals of the KM3NeT science program, several new challenges have to be addressed in areas such as marine engineering, electronics, detector simulations, computing, physics sensitivity studies and statistical analyses. Many challenges in the aforementioned areas are shared by other projects around the world. The accomplishment of many goals for KM3NeT is intimately linked to the outcome of other research programs, in particular in the particle physics and astroparticle physics communities. To this end, it is necessary for the KM3NeT scientists to collaborate with researchers from the global scientific community.

In order to assess the feasibility of a sustainable long term collaboration, a Pilot Exchange Program (PEP) is being executed in the year 2019. Under this program, a total of three researchers and two master students were invited to work at KM3NeT member institutions. The researchers were chosen at different stages of their academic career: a PhD student, a Postdoctoral associate and a senior faculty member. Both students were enrolled in the last year of the master in Physics courses. The total duration of the program was one month in each case. A procedure for the selection of candidates was formulated (see deliverable D6.2). In the PEP exchanges, research activities were carried out for dark matter indirect search analysis, for neutrino interaction systematic studies and for the calibration of the detector. The following sections summarize the procedure followed for PEP and the research work carried out.

2 Selection of candidates

A questionnaire was prepared and circulated by the corresponding contact people in each country to formalize the rules for the PEP [cf. Deliverable D6.1 of this project]. Following it, a selection committee was formulated to select the candidates [cf. D6.2]. For the pilot stage, we have followed the procedure proposed in D6.1 as much as possible in practice. The main difference has been that in order to speed up the procedure and ensure that the stages of the candidates could be organized within the time framework of the project, we renounced an open call; instead, suitable candidates were contacted and solicited to participate. The PhD student, the postdoc researcher and the senior candidate sent their corresponding research proposals and CVs to the selection committee, which approved the selections. As discussed below, the participants in the program were Andrey Romanof (Moscow State University), Godefroy Vannoye (Ecole Normale Supérieure de Lyon), Nadège Iovine (Université Libre de Bruxelles), Marco Roda (University of Liverpool), Costas Andreopoulos (University of Liverpool) and Júlia Tena Vidal (University of Liverpool). The expenses of the latter were covered by her home institution.

It has to be mentioned that as a preparatory step for the future implementation, information on this program has been spread in the workshops organized by this and other working groups of the project.

3 Organisational arrangements

Using the grant money, travel, accommodation and per diem expenses for each of the three researchers were fully covered. Following the host institution rules, the PEP visitors were asked to make travel and accommodation arrangements by themselves through third party vendors. During their visit, the expenses were reimbursed. The living expenses for the master students were, instead, supported by their home Institutions. A good coordination from the host institute administrative staff was experienced for the reimbursement procedure. Each participant was assigned an office and a work place at the host institute during their visit.

4 Details of Visits

Table 1 shows the name and the dates of the PEP visitors. Although five participants were invited under the PEP, a total of six participants were finally received. The additional visitor, Ms. Julia Vidal-Tena, PhD student of Prof. Costas Andreopoulos, also participated in this work.

Name	**Position**	**Institute**	**Dates of the Visit**
Andrey Romanov	Master Student	Moscow State University (MSU)	June 10 - July 12 2019
Godofroy Vannoye	Master Student	ENS Lyon	May 20 – August 2 2019
Ms. Nadège Iovine	PhD Student	IIHE, Brussels	June 17 – July 19 2019
Ms. Júlia Vidal-Tena	PhD Student	University of Liverpool	July 8 – July 19, 2019 October 21- October 31, 2019
Dr. Marco Roda	Postdoctoral associate	University of Liverpool	July 8 – July 19, 2019 October 21- October 31, 2019
Prof. Costas Andreopoulos	Professor of Physics	University of Liverpool	July 8 – July 19, 2019 October 21 – October 31, 2019

Table 1: List of the participants in the pilot exchange program.

The student Andrey Romanov was already in contact with the KM3NeT group in Genova for the analysis of the Moon Shadow in atmospheric muons using the data of the ANTARES experiment, the neutrino underwater detector close to the ORCA site. During his stay, under supervision of senior staff personnel, Andrey has studied the possibility to extended this approach also to the KM3NeT ARCA and ORCA detectors.

The second student, Godefroy Vannoye, had never been in contact with the KM3NeT Collaboration before. Godefroy was therefore trained to the activity of the KM3NeT group in Genova which includes various physics analyses, detector calibration and integration of the Detection Units (DUs). In order to fit to the skills of Godefroy, he was assigned the study of the phototubes of one Digital Optical Module in one DU. During his stay he could successfully complete this task which was to our and to his opinion very useful for his education. Likely, a further exchange will be organised during his PhD thesis.

Ms. Nadège Iovine worked with Dr. Rebecca Gozzini on a study to combine data of the experiments KM3NeT, IceCube and ANTARES to perform an indirect dark matter search. Such searches target a very elusive signal, hence considerable progress is in reach joining data set from different experiments. The main achievement of a combined analysis is improving upon existing limits on dark-matter annihilation using data sets from several experiments with comparable sensitivities. This project has also allowed us to unify the analysis frameworks used by the respective collaborations.

In this perspective, ANTARES and KM3NeT have started a collaboration with the IceCube neutrino telescope. Ms Nadège Iovine is the corresponding contact for IceCube and she has developed the kernel of a combined analysis under the supervision of Juan Antonio Aguilar (ULB Brussels). The purpose of her visit to IFIC was to apply her analysis to KM3NeT simulated data. Ms Nadège Iovine and Dr Rebecca Gozzini have worked in close cooperation to achieve a data unblinding within the KM3NeT and IceCube collaboration, which was granted upon several interactions with reviewers from both collaborations. The current limits on dark-matter annihilation in the Galactic Centre have been improved in the energy region of interest between 50 GeV and 1 TeV [7].

The other three visitors are from the University of Liverpool and are members of the GENIE collaboration. Prof. Costas Andreopoulos is a lead author of the neutrino event generator GENIE [6], which is used by virtually all neutrino oscillation experiments around the world. The KM3NeT-ORCA experiment Monte Carlo (MC) simulations are built upon GENIE. Dr. Marco and Ms. Júlia Tena currently work in the same group on GENIE model tunes. During their visit, they interacted with the KM3NeT hosts Dr. Tarak Thakore and Dr. Juande Zornoza . For the second visit of this group, the PhD student Víctor Carretero also participated in the work. The visitors were given an overview of the ORCA oscillation program and details of MC simulations. The primary goal of ORCA is to determine the Neutrino Mass Ordering (NMO) with atmospheric neutrinos. The sensitivity to the NMO largely arises in the neutrino energy range 4 GeV -10 GeV. In this energy range, neutrino interactions occur via Quasi-Elastic (QE), Resonant (RES) and Deep-Inelastic (DIS) mechanisms. The modelling of these processes is challenging theoretically. The systematics related to neutrino interaction models may cause biased measurements of oscillation parameters at ORCA. These have not been studied so far. Prof. Luis Alvarez-Ruso, who is an expert in this area, based at IFIC, was also invited to join this discussion.

It was proposed by the visitors to run the ORCA simulations with different GENIE model tunes. This would help to identify the dominant cross section model parameters. They also suggest to adapt the analyses schemes used in the T2K experiment for ORCA analysis. Following their first visit, the IFIC hosts are currently adapting the ORCA simulation chain codes for the proposed studies. During the next visit by the participants, the work is expected to make further progress.

5 Return of Experience and Conclusions

The overall PEP experience was productive. Although not primary goal of the task described in this report, it should be mentioned that scientific output has been quite rich, as described above. Concerning the main goal, the preparation of an exchange program and the identification of the corresponding challenges, the following conclusions have been found (see also deliverables D6.1 and D6.2).

It was earlier suspected that it may be difficult for the participants to spend a full month in KM3NeT, as it might overlap with their regular obligations such as teaching. This seems to be particularly likely in the case of senior researchers. The GENIE group decided to split their visit into two parts, each for a duration of two weeks. It was also helpful that they had other collaborators at the host institution, IFIC. As it happened in this specific case, the entire local GENIE group desired to travel together, so that they could also continue their routine work and with other collaborators at IFIC. In such cases itt is thus advantageous to involve a large host institution to provide this opportunity.

The PEP has also shown than the return of the investment in bringing external experts to the Collaboration may be enhanced by the fact that the home institutes of the guests also contribute to part of the expenses, or like in the case of Júlia Tena, to enable the exchange of an extra researcher.

One of the future challenges of this program is that there are differences between the rules in different countries (and even for institutes in the same country) to implement these agreements. In order to mitigate this, there is the plan to allocate 15,000 euros per year for the scientist exchange program in the common fund foreseen in the statutes for the future legal entity [cf. WP 2], so as to decouple the implementation of the exchanges from local rules at the host institutes. This funding will ensure the sustainability of the exchange program for future participants in the program following the selection procedure which has been set up. In the meantime, cooperation with the participants in this pilot program continues at present.

Figure 1: Participants in the pilot exchange program at IFIC. From left to right: Marco Roda, Júlia Tena, Costas Andreopoulos, Tarak Thakore, Juan de Dios Zornoza, Rebecca Gozzini and Nadège Iovine.

6 References

1. *Letter of Intent for KM3NeT 2.0.* **Adrián-Martínez, S., et al.** 2016, Journal of Physics G: Nuclear and Particle Physics, Vol. 43 (8), p. 084001. arXiv:1601.07459 [astro-ph.IM]. DOI: 10.1088/0954-3899/43/8/084001.

2. **KM3NeT Collaboration.** KM3NeT Homepage. [Online] 2017. https://www.km3net.org

3. "KM3NeT/Super-ORCA: Measuring the leptonic CP-phase with atmospheric neutrinos – a feasibility study," J. Hofestädt, T. Eberl, M. Bruchner, Neutrino 2018, https://doi.org/10.5281/zenodo.1292936

4. The physics potential of a neutrino beam from Protvino to ORCA", J. Brunner, Neutrino 2018, https://doi.org/10.5281/zenodo.1300743

5. "NuSTEC White Paper: Status and challenges of neutrino–nucleus scattering", L. Alvarez-Ruso at. el., Prog.Part.Nucl.Phys. 100 (2018) 1-68

6. "The GENIE Neutrino Monte Carlo Generator", C. Andreopoulos, et. al., Nucl.Instrum.Meth. A614 (2010) 87-104

7. "Combined Search for Neutrinos from Dark Matter Annihilation in the Galactic Centre using ANTARES and IceCube", N. Iovine, J.A. Aguilar Sanchez, S. Baur, S.R. Gozzini, J.D. Zornoza Gómez, PoS (ICRC 2019) 522